



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A44B 18/00, B29C 17/00, D06C 3/00, B29D 5/00		A1	(11) International Publication Number: WO 98/32349
			(43) International Publication Date: 30 July 1998 (30.07.98)
(21) International Application Number: PCT/US98/01271		(74) Agent: WILLIAMS, John, N.; Fish & Richardson, P.C., 225 Franklin Street, Boston, MA 02110-2804 (US).	
(22) International Filing Date: 23 January 1998 (23.01.98)			
(30) Priority Data: 08/789,637 27 January 1997 (27.01.97) US		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).	
(63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Application US 08/789,637 (CIP) Filed on 27 January 1997 (27.01.97)			
(71) Applicant (for all designated States except US): VELCRO INDUSTRIES B.V. [NL/NL]; Castorweg 22-24, Curacao (AN).		Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.	
(71)(72) Applicant and Inventor: BUZZELL, Keith, G. [US/US]; 18 Greenfield Road, North Waterboro, ME 04061 (US).			
(72) Inventors; and			
(75) Inventors/Applicants (for US only): PROVOST, George, A. [US/US]; 27 Brook Road, Litchfield, NH 03103 (US). MAYDRA, Richard, G. [US/US]; 30 Hanover Street #404, Manchester, NH 03101 (US).			
(54) Title: STRETCHED FASTENERS			
(57) Abstract			
<p>A running length of fastener product (10) is formed of longitudinally pre-oriented synthetic resin. The product is characterized by a base web and an array of discrete fastener elements (A) protruding from at least one side of the web (12) being in a laterally stretched molecular oriented condition. After forming a preform having discrete fastener elements (11) integral with a base web (12) in a stretchable state, the preform is stretched in a manner that substantially increases the fastener element spacing and reduces the thickness of the base web (12). A machine (40) is shown that is capable of lengthwise orienting before forming and widthwise stretching after forming, which employs controlled heating to render the product widthwise stretchable while preserving or achieving a desired shape of the fastener elements (11). There are shown fastener products (10) that include products that are laterally stretched to between two and ten times the width of the original preform fastener products (10), having lateral rip resistance due to molecular orientation of film form webs (12) produced by stretching, applied to complex or extensive surfaces. Also shown are laminated products formed by joining an added material to the stretched web (12), and methods for laminating.</p>			

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

- 1 -

STRETCHED FASTENERS

Background of the Invention

This invention relates to sheet-form fastening
5 members of synthetic resin and to methods and machines
for their manufacture.

An important aspect of the invention concerns hook
fastener members for hook and loop fastening. These are
formed of synthetic resin in running lengths. Typically
10 there are multitudes of fastener elements, i.e. hundreds
or even thousands of discrete hook elements per square
inch. These are typically arranged in neat rows in the
machine direction, i.e. in the direction in which the
forming system produces the product.

15 These hook elements stand discretely from at least
one side of an integral web-form base. The base forms
the means of attachment of the fastening member to the
article that carries it.

Fastener members with fields of such hooks
20 typically have a pleasing, uniform, commercially
acceptable appearance and are widely found in consumer
and industrial products.

In a preferred method of manufacture, molding
rolls are used in the process shown e.g. in Fischer U.S.
25 Patent No. 4,794,028. This process produces hook
fasteners of commercial appearance in which the rows of
hooks are straight and the spacing between the hook
elements in both directions is regular.

Mold rolls for forming preferred fastening members
30 of this kind typically comprise a series of thin circular
plates, with mold plates alternating with spacer plates.
Peripheries of the individual molding plates are machined
with cutouts to define small hook profile cavities. The
group of plates is held so their peripheries cooperate to
35 define the surface of the roll. Because a large number
of such plates is required and the plates must be

- 2 -

carefully held in alignment, such mold rolls have been expensive to produce and maintain and have typically been confined to short lengths. The width of the product produced has been correspondingly restricted.

5 Conventional fastener materials produced in this way have been less than one or two feet in width and have had a web thickness between the hooks greater than 0.005 inch, typically 0.008 inch or more. Typically, in this method of manufacture, the hooks face in the machine
10 direction or in the opposite direction, with the consequence that their major peel and shear strengths have been similarly oriented.

In certain of its broadest aspects the invention to be described applies to other techniques for forming
15 fastener members of synthetic resin as well as the molding technique just described. Using such techniques, for instance, using the known cut and stretch techniques on an extruded preform, a field of discrete fastener elements also stands up from a base and the fastener
20 elements are aligned in rows extending in the machine direction. In this way the hooks are oriented transversely to the machine direction and have their principal peel and shear strengths in just that direction. Machines and processes which have produced
25 such devices have been limited in the width of the formed product and in the minimum thickness of the web that can be achieved between the fastener elements.

Summary of the Invention

We have discovered that it is possible to achieve
30 a commercially acceptable sheet-form fastener member of synthetic resin in which the web or base portion lying between the multitude of fastener elements exists in a laterally permanently stretched condition, in many instances the substance of the web having molecular

- 3 -

orientation at least partially in the direction of lateral stretch.

We have found that, while preserving the identity and functional shape of integral discrete fastener elements, the web portions between neighboring fastener elements can be stretched to a uniform thickness across the width of the product. In desirable instances, the web portions between the fastener elements are reduced to film thicknesses, and the resulting fastener member is readily conformable about curved or complex surfaces or is otherwise usefully applied to broad areas in an economical manner.

According to one important aspect of the invention a method of producing a sheet-form fastener product comprises the steps of: (1) lengthwise stretching a sheet of heat-softened synthetic resin to pre-orient the molecular structure of the sheet in a longitudinal direction; (2) with a rotating mold roll, molding from the sheet a running web having a base and a multiplicity of discrete fastener elements integral with the base and protruding from at least one side of the base; and (3) thereafter, under conditions in which the web is permanently stretchable, stretching the web widthwise in a manner that permanently stretches the base and increases the widthwise spacing of the fastener elements.

In some particularly useful embodiments, the fastener elements comprise touch-fastener hooks or the like.

Advantageously, in preferred embodiments, the widthwise molecular orientation and peel strength of the fastener product are increased during the widthwise stretching process.

In the presently preferred configuration, the ratio of the final width of the product to the original width of the product before widthwise stretching is

- 4 -

between about 2 to 1 and about 10 to 1, and the widthwise stretching reduces the thickness of the base of the web by at least 50%.

In certain configurations, the widthwise stretching widens the web by at least 200% and reduces the thickness of the base of the web between fastener elements by at least two thirds.

In another embodiment, the method also comprises heating the web to render the base of the web permanently stretchable without detrimental change in the shape of the fastener elements. In certain arrangements, the fastener elements protrude from only one side of the web and the web is heated predominantly from a side opposite the side having the fastener elements.

15 In some examples, the resin is a thermoplastic resin suitable for forming hooks, comprising polypropylene, polyethylene, polyester, polystyrene, PVC, nylon or copolymers or polymer blends thereof.

20 In certain advantageous configurations, the widthwise stretching process causes molecular orientation and strengthening of the base of the web between fastener elements as it is stretched, such that as a result the base of the web between fastener elements is stretched widthwise substantially uniformly throughout.

25 In certain situations in which the synthetic resin has a Characteristic Minimum Stretch Ratio, the mold roll defines fastener elements and other stretch-limiting features over the area of the web, according to a predetermined pattern. The pattern is selected such that 30 the ratio of the width of the final web to the width of the web before widthwise stretching is substantially less than the Characteristic Minimum Stretch Ratio. In certain useful embodiments, the fastener elements and stretch-limiting features resist local stretching of the 35 web. In some situations, the stretch-limiting features

- 5 -

are physical features of the product formed of synthetic resin integral with the base of the web, with the method including the step of differentially heating the web being formed such that the fastener elements and the 5 stretch-limiting features are rendered less stretchable than the base of the web.

In some configurations, the temperature of the web base is controlled as the web is stretched widthwise. For instance, the fastener elements may be immersed in a 10 temperature-controlled liquid during the widthwise stretching. In other instances, the web base is immersed in a temperature-controlled liquid during the widthwise stretching, or the web base is heated in a heated liquid bath during the widthwise stretching while leaving the 15 fastener elements exposed to air.

In some embodiments a dual stretch process is employed, in which the step of stretching the web widthwise includes stretching the web widthwise in a first stretch zone, maintaining the web at an 20 intermediate, stretched width, and then further stretching the web widthwise in a second stretch zone. Preferably, the rate of widthwise stretching varies along the first stretch zone.

In another aspect of the invention, a method is 25 provided for producing a sheet-form fastener product, comprising (1) forming from synthetic resin a running web having a multiplicity of rows of discrete fastener elements integral with and protruding from at least one side of base of the web, the elements facing in a 30 substantially longitudinal direction, and (2) thereafter, under conditions in which the web is permanently stretchable, stretching the base of the web in a bias direction in a manner that permanently stretches the web base between fastener elements, increasing the spacing of 35 the fastener elements and orienting the rows of fastener

- 6 -

elements in a direction diagonal to the machine direction, such that the elements face in a diagonal direction.

In another aspect of the invention, a method of 5 producing a laminated sheet-form product having fastener elements comprises (1) forming from synthetic resin a running web having a multiplicity of discrete fastener elements integral with a base of the web and protruding from one side of the web base in a pattern, (2) 10 thereafter, under conditions in which the web base is permanently stretchable, stretching the web base widthwise to a wider width in a manner that permanently stretches the web base between fastener elements and increases the widthwise spacing of the fastener elements 15 while substantially maintaining the longitudinal spacing of the fastener elements, and (3) bonding an added material to the oppositely directed side of the web base.

In some embodiments the bonding comprises passing the added material and web over a roller under conditions 20 in which the web base is heat-softened.

In other embodiments, the bonding comprises applying an adhesive to either the added material, or the web base, or both, and directing the added material and web to join to form a laminate.

25 In yet other embodiments, the bonding comprises heat-softening a surface of the added material, and passing the added material and web over a roller such that the web base adheres to the heat-softened surface of the added material.

30 In the preferred arrangement, the bonding includes forcing the added material and web together such that the web base adheres to the heat-softened surface of the added material, sometimes by forcing the added material and web together against a roller by air pressure.

- 7 -

In another aspect of the invention, a method of producing a sheet-form fastener product comprises (1) forming from synthetic resin a running web having a multiplicity of discrete fastener elements integral with 5 the web and protruding from at least one side of the web in a pattern, the forming causing the molecular structure of the web to be pre-oriented in a longitudinal direction, and (2) thereafter, under conditions in which the web is permanently stretchable, stretching the web 10 widthwise in a manner that permanently stretches the web between fastener elements and increases the widthwise spacing of the fastener elements while substantially maintaining the longitudinal spacing of the fastener elements.

15 In another aspect of the invention, a fastener product is comprised of synthetic resin and has multiple rows of fastener elements oriented in a first direction along a web base. The web portions between the rows of elements have molecular orientation at a substantial 20 angle to the first direction.

In a preferred arrangement, the fastener elements comprise hook elements with profiles set at a bias direction relative to the running length of the web.

25 In some cases the web base, in a stretched condition, comprises a thermoplastic film of thickness less than 0.003 inch. In certain cases, the product is adhered to a non-planar surface of a useful product, the film web conforming to the non-planar surface.

30 In some useful embodiments, the product has a width of eight feet or more.

In certain advantageous examples, the product has molecular orientation in the widthwise direction, providing tear resistance in the lengthwise direction.

In certain key embodiments, the product also has

molecular orientation in the lengthwise direction, providing tear resistance in the widthwise direction.

In another set of embodiments, a decorative covering comprises the product and a sheet material in a 5 laminated state, the fastener elements of the product providing a means to secure the covering in a desired position. In some instances, the decorative covering comprises a wall covering. In other instances, it comprises a floor covering.

10 In another aspect of the invention, a machine for forming a fastener product has a pair of rolls forming a nip, at least one of the rolls being a mold roll for forming touch fastener elements integral with a side surface of a running length of a web base. The machine 15 also includes means for supplying plastic resin to the nip, whereby the resin is longitudinally stretched before being molded, and a widthwise stretching device arranged to stretch the web base of an intermediate product produced by the pair of rolls in a direction transverse 20 to the running length of the web base.

In the presently preferred embodiment, the machine includes a heating tunnel through which the intermediate product is passed prior to the stretching device. The heating tunnel is arranged to predominantly heat a side 25 surface of the web base opposite to the side surface on which the fastening elements are disposed.

In a particularly useful embodiment, the means for supplying plastic resin comprises an extruder and the supplied resin is longitudinally stretched by tension 30 caused by the driven rolls, thereby pre-orienting the molecular structure of the resin in the machine direction before forming.

In another configuration, the means for supplying plastic resin comprises an extruder positionable above 35 the nip, and the supplied resin is longitudinally

- 9 -

stretched at least partially by inertial forces as it falls from the extruder to the nip.

In another useful arrangement, the machine also includes means for laminating an added material to the 5 stretched web base. In a preferred embodiment, the means for laminating includes a roller about which the product is trained in a stretched condition.

Brief Description of the Drawings

Fig. 1 is a side view and Fig. 2 is a plan view of 10 an apparatus for producing a product according to the invention.

Fig. 1a is an alternate source for the web that can be stretched in the system of Figs. 1 and 2.

Fig. 3 is a magnified plan view of the product 15 prior to widthwise stretching, taken on line 3-3 of Fig. 1.

Figs. 3a and 3b are cross sectional views taken along lines 3a-3a and 3b-3b, respectively of Fig. 3.

Fig. 4 is a magnified plan view of the completed 20 product, taken on line 4-4 of Fig. 1.

Fig. 4a is a magnified plan view of a completed fastener product in which the fastener elements are disposed at a bias angle relative to the machine direction.

25 Fig. 4b is a magnified plan view of a completed product which has been stretched both widthwise and lengthwise.

Fig. 4c is a magnified view of a completed product having differently shaped fastener elements.

30 Fig. 4d is a magnified view of a product having additional stretch limiting formations.

Figs. 5 and 6 are cross-sectional views of the completed product taken along respective lines in Fig. 4.

35 Figs. 5a and 6a are cross-sectional views taken along respective lines in Fig. 4a.

- 10 -

Figs. 5b and 6b are cross-sectional views taken on respective lines in Fig. 4b.

Fig. 7 is a side view and Fig. 8 an end view of the highly magnified fastener element of Figs. 5b and 5c, 5 illustrating the change in section dimensions of the product during stretching.

Figs. 7a-7d illustrate some of the many types of fastener elements that may be employed.

Figs. 9 and 10 are side views of objects to which 10 a fastening member according to the invention has been secured.

Fig. 11 is a diagrammatic plan view of a tenter frame constructed to effect stretching of the product in a bias direction.

15 Fig. 12 is a view similar to Fig. 11 of a tenter frame producing simultaneous widthwise and lengthwise stretch to bias the orientation of the fastener elements.

Fig. 13 is a view similar to the left-hand portion of Fig. 1, having the addition of means to introduce a 20 preformed fabric to the back of the web.

Fig. 13a is a cross-sectional view of a product formed employing the apparatus and method illustrated in Fig. 13.

Fig. 14 is a view similar to the left-hand portion 25 of Fig. 1 in which a coextrusion extruder supplies the nip with a molten resin of two different compositions.

Fig. 14a is a cross-sectional view of a product made with the process and machine of Fig. 14.

Fig. 15 is a view similar to that of the left-hand 30 portion of Fig. 1 incorporating multiple mold rolls for forming a product having projections on both sides, providing for multiple resins for constituting the product.

- 11 -

Fig. 15a is a cross-sectional view of a product formed employing the apparatus and method illustrated in Fig. 15.

Fig. 16 illustrates the use of radiant heating in 5 a preheating oven prior to lateral stretching.

Fig. 17 shows a version of the machine of Fig. 1 that laminates a backing material to the stretched web.

Figs. 18-20 illustrate additional lamination adhesion techniques.

10 Fig. 21 illustrates dual speed zone stretching.

Figs. 22-23 are side and plan views, respectively, of a liquid bath for maintaining the temperature of the fastener elements during stretching of the web.

15 Fig. 24 illustrates heating the web base in a liquid while exposing the fastener elements to air during stretching.

Fig. 25 illustrates a dual-liquid temperature control stretch bath.

20 Fig. 26 shows the fastener product being stretched while controlling the temperature of both the web and fastener elements in a single fluid medium.

Detailed Description of Presently Preferred Embodiments

Referring to Figs. 1 and 2, a forming device 13 is shown which employs a rotating mold roll 14 for molding 25 from synthetic resin a product 10 with a running web 12 having a multiplicity of discrete spaced-apart fastener elements 11 integral with the base web. As depicted in Fig. 1 the mold roll 14 is associated with a pressure roll 16 to define a forming nip. The mold roll has 30 discrete mold cavities about its perimeter, each shaped to form a fastener element profile, for instance that shown greatly magnified in Figs. 7 and 8. An extruder 18 extrudes molten plastic resin 20 which enters the nip and is formed into a web with a large multiplicity of the

- 12 -

discrete fastener elements extending from one surface. After passing about takeoff roller 22 the formed product 10 is available to be passed through the stretching apparatus shown in Figs. 1 and 2.

5 Alternatively, instead of passing the product 10 from the forming device 12 directly to the stretching system as shown in Figs. 1 and 2, the product may be accumulated in a storage roll and at another time it may be dispensed from the storage roll to the stretching 10 system. Fig. 1a shows a stand 24 mounting a storage roll 10a of material formed previously by forming device 12. The material passes about idlers 26 and 28 and is supplied to the stretching system of Figs. 1 and 2 to proceed as a batch process rather than as the in-line 15 process shown in Fig. 1.

In either process, the product 10 enters a stretching system comprising a preheater 32, a lateral stretching mechanism 40, and cooling unit 42. The completed product can then be wound into a roll or 20 otherwise processed.

Referring also to the magnified product view of Fig. 3, the upper surface of the web 12 has a great number of discrete upstanding hook elements 11, in this case suitable for fastening according to the hook and 25 loop technique. Alternate rows of the hooks may face in opposite directions, the rows of hooks being aligned with the machine direction T, corresponding to the direction in which the molding roll 14 turns.

Prior to entering the preheater 32, the product is 30 engaged by clamps 30 of the tenter frame which travel on rails along with the product, thus conveying the molded product through the preheater 32, and the lateral stretching unit 40.

As shown, the downwardly facing, smooth surface of 35 the web 10 of the product is exposed to distributed

- 13 -

currents of hot air that are generated by hot air source 34 and introduced to the preheater through plenum 36 and distribution nozzles 38.

The upper surface of web 10 and discrete fastening elements 11 are exposed to residual air currents at cooler temperature contained by the walls of the preheater 32. As a result, the majority of the heat is controllably introduced through the lower surface of the product and the fastener elements 11 on the upper side 10 are kept at a temperature sufficiently low that no detrimental deformation of the fastener elements occurs during the preheating and stretching processes.

The product 10 in preheater 32 is heated typically to a controlled temperature above the glass transition 15 temperature of the synthetic resin of which the product has been formed, but below its melting temperature. Due to the predetermined layout of the guide rails, the tenter frame clamps 30 maintain a constant widthwise spacing corresponding substantially to the formed width 20 of product 10, up to the final stage of the preheater 32. At this point the clamps 30 begin to diverge, in accordance with known tenter frame techniques. The 25 clamps diverge in the stretching unit 40 until the maximum width is achieved, as shown substantially midway in the stretching unit, after which the tenter frame rails may proceed in parallel for a selected distance and then gradually converge to the stabilized final width W. The product passes through the cooling unit, 50 with width W where the material is cooled and stabilized.

Referring also to Fig. 4, the result of passing of 30 the product through the preheater 32, stretching unit 40 and cooling unit 50 is that the web is permanently stretched widthwise, and the spacing between the rows of discrete fastener elements 11 is increased according to a 35 predetermined stretching ratio. This ratio is selected

to be in excess of the Characteristic Minimum Stretching Ratio of the resin, as explained more fully below. In comparing the before and after magnified views of the product, Figs. 3 and 4, it is seen that the initial 5 spacing w_0 of the rows of the fastener elements 11, Fig. 3, has increased to spacing w_1 , Fig. 4, which is significantly larger than w_0 . Depending upon the desired product, the characteristics of the resin being processed, and other parameters, the change in spacing, 10 w_1 may be selected to be between about 2 and 8 times the original width w_0 . Because the grippers 30 of the tenter frame move at a velocity V_1 that is substantially constant throughout the stretching system in this embodiment, no significant change is produced in the 15 lengthwise spacing of the discrete hook elements in the machine direction of travel, T , as indicated by the same dimension l_0 in Figs. 3 and 4.

In certain instances the widthwise stretching is performed in two or more distinct zones, as shown in Fig. 20 21. In the first zone Z_1 the product is stretched in a widthwise direction to an overall stretch ratio of about 2.5:1, after which it is maintained at an intermediate width for at least a few seconds to achieve partial stabilization before undergoing a second widthwise 25 stretch in zone Z_2 to a final overall stretch ratio of about 6:1. As illustrated, the tenter frame rails in the stretch zones follow curves (e.g., cosines) configured to gradually initiate and culminate the widthwise acceleration of each stretch cycle. The first stretch 30 cycle establishes the desired molecular orientation of the web base. This dual speed zone stretching arrangement may enable larger final stretch ratios to be achieved with sensitive web resins while avoiding tearing caused in part by process-induced stress concentrations 35 at the bases of the hooks.

- 15 -

Being thus subjected to lateral stretching conditions, the material of the base web 12 significantly decreases in thickness from the original thickness t_0 of Figs. 3A and 3B to the reduced thickness t_1 of Figs. 5 and 6. The areal density of the fastener elements is accordingly reduced. For example, with hook form elements of a type having a conventional height of about 0.035 inch and a spacing l_0 of about 0.050 inch along the rows, starting with a spacing w_0 of the rows of about 0.025 inch and ending with a spacing w_1 of Fig. 4 of about 0.100 inch, the areal density changes by a factor of 4, from about 800 fastener elements per square inch to about 200 fastener elements per square inch. In cases where a greater final area density of the hook elements is desired, e.g. for greater peel or shear strength of loop fabric, one can readily make adjustments, for instance by decreasing the stretching ratio. In another example employing smaller discrete fastener elements, the area density may change e.g. from about 2000 to about 1000 or 500 per square inch. Numerous different fastener element profiles may be employed with different area densities.

The stretching process is thus conducted under conditions in which the base web 12 is permanently stretchable the desired amount and the stretching of the web is conducted in the manner that permanently stretches the web 12 and results in increasing the spacing of the fastener elements 11 of the product 10. Numerous other arrangements can be employed, a few of which will be described later in this description.

In the preferred embodiment shown in Figs. 1 and 2, the web is rendered permanently stretchable by the application of heat. By use of heated air and avoiding

- 16 -

introducing the hot air to the top surface of the web 12, which in this case carries the integral molded fastener elements, the fastener elements 11 are protected from the heating conditions to which the under surface and body of 5 the web are subjected. Under these conditions, stretching the web 12 is found not to deleteriously affect the profile of the fastener hooks 11. The amount of divergence of the grippers 30 of the tenter frame and the final dimension W to which the web is stretched is 10 varied according to the resin employed and the desired characteristics of the final product.

Typically a given resin material as a flat sheet, under given stretching conditions, has a Characteristic Minimum Stretch Ratio (CMSR) defined by the condition 15 that, if the sheet is not stretched beyond that minimum ratio, a nonuniform product results, with ripples and dents. If the CMSR is exceeded, stretching of all areas can be assured, and a substantially flat final product can be achieved. This parameter is determined from the 20 manner in which stretching, at the microscopic level, occurs. In general it reflects the fact that molecular orientation occurs during the stretching that increases the strength of the region of the sheet where the orientation has occurred. Considering the stretching 25 action microscopically and over very short time intervals, the sheet is never precisely of uniform thickness or heated to a precisely uniform temperature and stretchability throughout. This affects the way the process proceeds. In the initial stages of the process, 30 the stretching occurs in the most stretchable regions until by progressive molecular orientation in those regions, those regions of the sheet become stronger and more resistant to stretching. As this occurs, the stretching action shifts to previously unstretched 35 regions, and so on. This creates a uniform stretching

- 17 -

effect if stretching occurs over a sufficient length of time and the CMSR is substantially exceeded, by which all regions of the sheet experience some stretching sufficient that a flat, uniformly appearing product is 5 achieved.

In the embodiment of Figs. 1 and 2, the longitudinal speed V_1 of the tentering frame clamps 30 is maintained substantially constant throughout the length of travel from preheater through the cooling unit.

10 Referring to Fig. 4a and to the diagrammatic representation of the tenter frame grippers in Fig. 11, in an alternative process the grippers along one edge of the product travel at velocity V_1 throughout the preheater 32 and stretching unit 40 as depicted.

15 However, along the other edge of the product, the gripper chain is divided into two effective sections. The first section passing through the preheater 32 travels at velocity V_1 , the same as the velocity on the opposite edge. In the second section, within the stretching unit 20 40, the longitudinal speed of the grippers is smoothly increased to a velocity V_2 which is faster than velocity V_1 . This has the effect of applying stretching forces to the web material in the diagonal or bias direction as suggested by arrow D in Fig. 11 and results in a 25 reorientation of the rows of fasteners to the relationship depicted in Fig. 4a. The rows of fastener elements form an angle α relative to the machine direction of travel, T. In this case the material of the base web 12 has molecular orientation set in the bias 30 direction, due to the diagonal stretching, corresponding to the direction of the reoriented rows of fasteners. Prestretching in the machine direction is not required in this case, but may be employed. As a component of their profile now lies in the lateral, or cross-machine 35 direction, the fasteners in the diagonally-stretched

product may provide a more effective hook and loop fastening relative to peel and shear, in the lateral direction, than do the equivalent fasteners if processed to produce the product of Fig. 4.

5 Due to the arrangement of the resin extruder 18, mold and pressure rolls 14 and 16, and the included nip, the extruded resin is pulled, or stretched longitudinally, as it enters the nip, thereby pre-orienting the molecular chains of the resin of the base 10 web 12 in a longitudinal direction, parallel to the rows of fastener elements 11 before being molded. Typically the amount of longitudinal pre-orientation increases with the speed of the extrusion and molding process. This pre-orientation of the web advantageously strengthens the 15 web in a longitudinal direction, and can decrease the longitudinal tear resistance for applications that entail subsequent splitting operations. The use of special dies in the extruder 18, such as coat hanger dies, can enhance this longitudinal pre-orientation, as can gravitational 20 feed system in which the extruded web of molten resin longitudinally stretches under inertial forces as it falls into the nip.

In machines with extruder arrangements which do not advantageously longitudinally pre-orient the web as 25 it enters the nip, a tenter frame arranged as illustrated in Fig. 12 can be employed to stretch the molded web longitudinally as well as transversely, to create the product shown in Fig. 4b. In this case the clamps on both sides of the stretching apparatus are divided into 30 two sections. The first section on each side travels at the velocity V_1 through the preheater 32, and the second section of the clamps travels at greater velocity V_2 as the web is pulled through the tenter frame 40. This has the effect of stretching the web longitudinally 35 simultaneously as the web is stretched widthwise,

- 19 -

resulting in biaxial resin orientation of the substance of the web and increasing the spacing of the hook form fastening elements to width w_3 and length l_3 , respectively larger than the original values w_0 and l_0 as depicted in 5 Fig. 3. One detriment of this particular method is that post-stretching in a machine direction limits the amount of transverse stretching that can be applied to a molded web, thereby limiting the achievable width of the final product.

10 Fig. 4c illustrates another product producible by the method of the invention in which, in addition to the discrete fastener hooks 11, further formations 60 connected to the hooks serve a reinforcing function with respect to the overall performance of the product. The 15 post-forming widthwise stretching process is effective for such products.

In Fig. 4d, surface formations 90 are set in a pattern predetermined to limit the stretchability of the overall product when it is heated. In this case the hook 20 form fastener elements 11 and the further stretch limiting formations 90 are for instance kept relatively cool and cooperate to limit the stretchability of the overall preform. By appropriate selection, the fastener elements 11 and additional formations 90 can provide for 25 a specific product design, and under selected process conditions, an effective minimum stretch ratio that is substantially less than the CMSR for a plain, flat sheet of the same thickness as the web 12 of the product in question. In this manner the preform is fashioned to 30 behave in the tenter frame in a manner different from that dictated directly by the CMSR of a plain web of the resin. By suitable choice of the size and location of the formations and hook elements, it is found possible to regulate the effective CMSR for the preform, and thus be 35 able to vary the amount of stretching that can be

- 20 -

achieved. This enables production of fastener products having different properties as desired. In the case of polypropylene, the CMSR is typically between about 6 to 1 to 8 to 1. However, by suitable selection of the area density, spacing and size of the hook elements 11 and the area density spacing and size of additional stretch limiting formations 90, and their relationship to one another, the effective CMSR for products may be variable over a considerable useful range, for instance down to 4 to 1 or 2 to 1. This may enable, by suitable selection of the parameters, forming products of numerous expansion ratios using the same resin, especially such resins as polypropylene.

Figs. 7a-7d illustrate some of the many other types of fastener elements that can be employed. The micro hook of Figs. 7a and 7b, have a characteristic height from about 0.030 inch down to 0.015 inch or less. These are useful for fine matching loop fabrics, including low loft nonwoven fabrics. The fastener element of Fig. 7c is of palm tree shape, and can have a height of about 0.100 inch, useful, e.g., for fastening upholstery fabrics to form creases and the like. Fig. 7d illustrates a mushroom-profile fastener element adapted to mesh with an array of similar mushroom fastener elements of an opposed fabric. This is given as just one example to show, that in its broader aspects, the invention is applicable to molded fastener elements of other forms. These are just four of the many hook profiles suitable for hook and loop fastening which can be employed advantageously in products produced in accordance with the invention.

Referring to the highly magnified views of Figs. 7 and 8, the dashed line portions of the figures denote the originally molded product 10 as it leaves the forming device 13. The effect of the heat and stretching reduces

- 21 -

the thickness of the web 12 as shown by the solid lines. The widthwise stretching can reduce the thickness of the web significantly, depending upon the stretching ratio.

Advantageously, in certain instances, the web is 5 reduced to film thickness, i.e., less than 0.003 inch thickness, for thick film, or between about 0.001 inch and 0.002 inch thickness for relatively thin film. Such films have substantial conformability to complex surfaces. In some cases conformability alone is 10 sufficient to enable smooth application to curved surfaces such as cylinders, or to be thermoformed. In other instances, the final thickness of the web, and the synthetic resin of which it is molded, are selected to impart stretchiness to the overall product to enable it 15 to be stretched about complex surfaces.

Advantageously, in some instances, the product is bonded to the surface of an article that adds strength to the overall fastener member. Bonding may be by use of the adhesive quality of the back of the resin web itself, 20 when heated as by flash heating, or by application of a layer of bonding agent, or by the adhesive quality of the surfaces to which it is applied, or by respective combination of any two or three of these, or by other bonding or adhering techniques, including ultrasonic 25 welding or the like.

In Fig. 9 is shown a complex surface to which has been conformed a fastener member 80 produced according to the invention in which the thickness of the base web of the product has been reduced to a selected thickness in 30 the range of 0.001 to 0.002 inch. The film-like nature of the web in this product renders it conformable and, where desired, stretchable, so that it conforms to the complex surface. In Fig. 9 the shape is arbitrary to illustrate the fact that numerous shapes can receive such 35 a fastener member.

- 22 -

In the diagrammatic view of Fig. 10, a wide surface is illustrated, for instance an interior surface of an office partition, e.g. of 5 feet by 7 feet dimensions, to which a sheet of the material formed 5 according to the invention has been adhered. The material provides a uniformly covered array of hooks over the entire surface as desired. A surface such as this can receive a loop member at any point and hold it securely. In this manner, partition walls of contrasting 10 colors may be joined; signs and art work may be mounted on walls, ceiling tiles may be affixed, floor coverings may be secured, etc., all at relatively low cost.

Referring back to Figs. 7 and 8, it is shown by the dashed lines that the height of the hook fastener 15 element prior to heating was greater than after being subjected to the heating and stretching process.

Depending upon the controlled amount of heat applied in the preheater 32 to the fastener elements, a certain amount of superficial flow of material from the fastener 20 element may occur to effect shortening, due to controlled surface melting combined with gravity and surface tension effects. This can give the outer surface of the array of hook fasteners a desired effect, e.g., a softer and more pleasant surface "feel" for contact with the skin, for 25 cases where such contact may occur.

In other instances, where it is wished to preserve the precise molded shape of the fastener elements 11, change to the profile can be avoided by reducing the heat applied or protecting the fastener elements while the web 30 12 is being heated. In this case the tension forces, applied to the web during stretching, extend into the relatively cool protruding fasteners element structure and effectively pull these relatively rigid structures into the relatively softer web material.

- 23 -

As shown in Figs. 22 and 23, one method of protecting the fastener elements during stretching employs a shallow, temperature-controlled liquid bath 120. In this instance, only the fastener elements 11 are 5 submerged in the bath during widthwise stretching, with the web base 10 exposed to an air environment of a higher temperature than the bath. The tenter frame rails 31 are arranged to lower the web to submerge the fastener elements during stretching, and to lift the product from 10 the bath after stretching.

In another configuration illustrated in Fig. 24, the lower surface of the web base 10 is submerged into a heated, temperature-controlled bath while the fastener elements 11 are exposed to cooler air. In yet another 15 configuration (Fig. 25), two non-mixing liquids 125 and 126 are employed and maintained at separate temperatures with the web base running along the interface between the two liquids acting as a thermal barrier to reduce heat transfer between the layers. In each of the above 20 configurations, the bath is employed to more precisely control the temperature of the web base separate from the temperature of the fastener elements so as to help to maintain a desired fastener element shape as the web is stretched. The liquid bath may be arranged such that the 25 fastener product is either suspended in the liquid or supported by the lower surface of the bath. In the configuration shown in Fig. 26, the entire fastener product (i.e., the web base 10 and the fastener elements 11) is submerged in a temperature-controlled fluid 30 (either bath liquid or oven air) to control the temperature of the product during stretching. Useful bath liquids include glycol, for instance.

An aspect of the invention is the discovery that the tension effect between the base and fasteners is 35 controllable, does not prevent the stretching of products

- 24 -

having discrete, small fasteners elements, and in fact, in certain instances, can be used to advantage to achieve a desired shortening or change of geometry to the fastener elements.

5 Many of the foregoing embodiments have dealt with a fastener element having a single constituent resin of which the fastener elements 11 and the base portions 12 are integrally formed. Other constructions likewise take advantage of the invention, and in some instances provide 10 further improved results.

Referring now to Fig. 13, the forming system is as shown in Fig. 1 with the addition of a wide roller 17 arranged to draw a preformed web 19 from a source not shown and supply it to the surface of the lower roll 16 15 preceding the nip. The material 19 comprises a knitted product which has been precompressed, for instance by a process known as microcreping, available from Micrex Corporation, Walpole, Massachusetts. The knitted fabric is suitable for engagement with the hooks formed by the 20 apparatus, and is capable of undergoing widthwise stretch without tending to shorten longitudinally. It is introduced to the surface of the roll 16 prior to the nip, and is combined with the resin 20 in accordance with the concept disclosed in U.S. Patent 5,260,015, which is, 25 in its entirety, hereby incorporated by reference. The resulting material is shown in the magnified view of Fig. 13a. The hook elements 11 are, as before, integrally formed with the base web 12, but the underside of the web is commingled and intimately joined with fibers of the 30 compacted knitted fabric 19 to form a integral product. In one example the knitted product 19 is formed of fibers having a higher melt and glass transition temperature than that of the resin forming the web 12 and hook elements 11 such that the knit readily retains its looped 35 construction under the heating conditions of the oven

- 25 -

preheater 32 of Figs. 1 and 2. Thus, as the hot air currents from hot air source 34 of Fig. 2 permeate the porous knitted fabric and contact the resin, the knitted structure remains intact and in fact serves as a heat 5 sink to ensure the transfer of heat to the web 12 and provide for its stretchability when the product reaches the stretching region of the system.

In this manner a product having touch fastener hooks on one side and touch fastener loops on the other 10 side is produced, having a finished width which is significantly greater than the width of the product as it leaves the mold roll 14.

Referring to Fig. 14 a further embodiment employs the roll setup as shown in Figs. 1 and 2. However, the 15 extruder 18a is a coextrusion extruder and produces streams of resin 21 and 23 of different properties. Prior to reaching the outlet of the extruder the streams 21 and 23 are merged and the combined extrudate 20a is fed into the nip of the mold roll and the pressure roll 20 16 as a layered composite of the two resins. The resin 23 may have a lesser thickness than resin 21, resin 23 being selected to form principally the fastening elements 11 while the resin 21 forms principally the web 12'. By employing compatible resins which have different 25 rheological qualities, some advantages are obtained in the later stretching process. As an example it is advantageous to select the resin 23 to have a higher melting point and a higher glass transition temperature than that of resin 21. Thus in the molded product, the 30 fastener elements 11' are comprised at least in part of resin 23 and are rendered less soft and less susceptible to deformation by the heat of preheater 32, and so more accurately preserve their profile when subjected to sufficient heat to render the resin 21 of the web readily 35 stretchable. Other advantages of Fig. 14 and the product

formed thereby is that the resin 23 of the hooks 11' (Fig. 14a) can be selected for its properties related to peel and shear strength of the fastener elements 11', whereas the resin 21 of the base web 10' can be selected 5 for optimal base web properties, for instance stretchability and conformability.

In Fig. 15 a system is shown comprising two mold rolls 14 and 14a forming a nip into which resin from extruder 18 is directed as provided in Figs. 1 and 2. 10 However, two additional extruders 18a and 18b are provided to apply resin to fill the mold cavities of the respective rolls 14a and 14. In one instance, as suggested by rolls 23 and 25, supplemental nips may be formed with the respective mold rolls into which the 15 resin from the supplemental extruders 18a and 18b is directed. In this case the gap of the rolls 23 and 25 relative to their respective mold rolls is reduced to a minimum so that the major portion of the resin enters the mold cavities. Alternatively, doctor blades may be 20 arranged to force resin into the mold cavities but to leave substantially no resin on the periphery that would enter the constituent of the base web. The resulting product has fastener elements 11 on one side and other elements protruding from the opposite side, for instance 25 fastener elements 11'. The resins chosen to be extruded from supplemental extruders 18a and 18b can be similar to that resin 23 which is employed in Fig. 14, i.e. they may have greater stability under the preheating conditions than the resin forming the main body of the web 12' and 30 the capability to retain their shape and integrity while the web of base resin provided by extruder 18 is heated and stretched. The product resulting from the process and use of the machine described in Fig. 15 is shown in Fig 15a in which the base web 10' is comprised of one 35 resin, the upper fastening elements 11 are formed of a

- 27 -

second resin, and the lower fastening elements 11' are formed of a third resin.

As depicted in Fig. 16, a radiant preheater 32a can be employed in which radiant elements 35 direct 5 radiant energy to the product 10 to bring it to stretchable condition. Advantageously the resin provided by the supplemental extruders 18a and 18b may be of a reflective or light colored pigment that limits the amount of absorption of radiation by the projecting 10 elements 11 and 11' whereas the resin provided by extruder 18 may for instance be black or otherwise highly absorptive to receive and absorb the radiant energy. (A similar function may be served by the resin provided in Fig. 14, for forming the fastener elements 11'.) 15 Advantageously in certain instances the resin chosen for extruder 18a has different properties than the resin chosen for extruder 18b. For example, in one case the resin chosen for extruder 18a is selected to solidify more quickly than that of the resin of extruder 18b and 20 be more readily separable from its mold roll at the nip, the resin for extruder 18b having longer time to cool as movement progresses with the roll 14 toward stripping roll 22a.

Whereas preheaters have been discussed in respect 25 of all the preceding embodiments, in another embodiment arranged for inline production, the lateral stretching is conducted close to the mold roll 14 and receives the product 10 directly from the controlled-temperature roll in a soft and stretchable condition. In this case the 30 heat of the extrusion and forming process is employed to provide the web in stretchable condition for the action of the lateral stretching unit 40. In this connection, it is noted that the projecting fastener elements 11 have significant exposed surface area relative to their volume 35 and under the appropriate conditions, cool more quickly

- 28 -

than the base web 12, and thus are more solid and resistant to deformation during the stretching process than is the base web itself, which, in most cases, is desired.

5 In another embodiment an added material is laminated to the stretched product on the side of the web opposite the fastener members, as shown in Fig. 17. After leaving tenter frame 40, with the back surface of the web 99 of the product in a heat-softened condition, 10 added material 100 from a source spool 102 is brought into contact with the back surface of the web as the web is passed over a laminating roller 104 before being spooled on takeup roller 106. In the embodiment shown, the web 99, under a degree of tension, is trained about 15 an arc of the laminating roll, which thereby exerts pressure between the web 99 and the added material. The softened web 99 permanently adheres to added material 100 applied by the laminating roller, to form a two-sided product 108 that may be many feet wide, with fastener 20 members on one side and the added material on the other side.

In one embodiment, the added material is a wall covering to which hooks are thus applied for removably fastening the wall covering to a wall.

25 In another embodiment floor mats, e.g. for automobiles, are produced, with the added material comprising fibrous carpeting on the top, and molded fastener hooks underneath to secure the floor mat to the permanent floor covering of the automobile.

30 In another embodiment, area rugs are formed, with the added material providing a top rug surface and the web providing fastener elements to fasten to a permanent floor covering.

For making these and other products, in certain 35 embodiments, further steps are employed to achieve

- 29 -

adhesion between the added material and the web that carries the fastener elements. For example, in one instance (Fig. 18), an adhesive 110 is applied to the added material (and/or web) before it is laminated to the 5 web. In another arrangement (Fig. 19), the added material and web are "flame-laminated" by flame-softening (in some cases, actually setting fire to) the added material (and/or web) before laminating. In yet another configuration (Fig. 20), air jets 112 help to press the 10 two layers of the laminate together against the laminating roller to augment the adhesion of the layers. Combinations of these and other adhesion-enhancing techniques are likewise useful.

A number of products demonstrate the practicality 15 of the invention. The following examples are given:

In a first example, a 12 melt flow polypropylene with a glass transition temperature near room temperature was molded to produce hook-shaped fastener elements with an overall height of about 0.035 inch, and an area 20 density of 750 hooks per square inch, on a 0.012 inch thick, 12 inch wide, web. Batches of the molded product were stretched to final widths of 3, 4, 5 and 6 feet, resulting in web thicknesses of 0.005, 0.004, 0.003 and 0.002 inch, respectively. Little or no hook deformation 25 occurred during the stretching process.

In another example, a fractional melt flow polypropylene was molded to produce hooks 0.028 inches in height with an area density of 900 hooks per square inch. Rip-stop formations were molded with the fastener 30 elements on a web of about 0.005 inch thickness. The product was stretched widthwise to ratios of 3:1 and 4:1, reducing the web thickness to 0.0015 and 0.001 inch. It was noted that the resulting web thickness was more uniform across the product at the higher stretch ratios. 35 Again, little or no deformation of the fastener elements

- 30 -

occurred during the stretching, producing a usable fastener strip with widths of 30 and 40 inches.

The same product as the above example, after being stretched to twice its width in a tenter frame, was 5 trimmed to lengths of the original width and run through the tenter frame again to perform a 2:1 lengthwise stretch. The final web thickness was about 0.001 inch, with the spacing between fastener members doubled in both the widthwise and lengthwise directions.

10 A 12 inch nylon 6/6 fastener strip was produced by stretching a 6 inch wide web with 0.100 inch high hooks arranged with an area density of about 147 hooks per square inch. The web thickness was reduced in half to about 0.006 inch.

15 A bottle grade polyethylene terathalate with a glass transition temperature of about 150 degrees Fahrenheit was used in the same molding apparatus as in the nylon example above, and then stretched to four times 20 its molded width to produce a very flexible fastener product four feet wide with a web thickness of only 0.001 inch.

A low density polypropylene with a glass transition temperature well below room temperature was molded to produce a 0.008 inch thick, 12 inch wide web 25 with 0.035 inch high hook-shaped fastener elements with an initial area density of about 750 hooks per square inch. An attempt to stretch the product to a final width of four feet resulted in localized tearing and a reduction in the height of the hooks. Usable product was 30 produced in stretched widths of two and three feet with little or no hook deformation and web thicknesses of 0.004 and 0.003 inches.

- 31 -

What is claimed is:

1. A method of producing a sheet-form fastener product comprising:
 - a. lengthwise stretching a sheet of heat-softened synthetic resin to pre-orient the molecular structure of the sheet in a longitudinal direction;
 - b. with a rotating mold roll, molding from said sheet a running web having a base and a multiplicity of discrete fastener elements integral with the base and protruding from at least one side of the base; and
 - c. thereafter, under conditions in which the web is permanently stretchable, stretching the web widthwise in a manner that permanently stretches the base and increases the widthwise spacing of the fastener elements.
- 15 2. The method of claim 1 wherein the fastener elements comprise touch-fastener hooks or the like.
3. The method of claim 1 in which the widthwise molecular orientation and peel strength of the fastener product are increased during the widthwise stretching process.
- 20 4. The method of claim 1 wherein the ratio of the final width of the product to the original width of the product before widthwise stretching is between about 2 to 1 and about 10 to 1.
- 25 5. The method of claim 1 in which the widthwise stretching reduces the thickness of the base of the web by at least 50%.
- 30 6. The method of claim 1 in which the widthwise stretching widens the web by at least 200% and in which the widthwise stretching reduces the thickness of the

- 32 -

base of the web between fastener elements by at least two thirds.

7. The method of claim 1 further comprising heating the web to render the base of the web permanently 5 stretchable without detrimental change in the shape of the fastener elements.

8. The method of claim 7 in which the fastener elements protrude from only one side of the web and the web is heated predominantly from a side opposite the side 10 having said fastener elements.

9. The method of claim 1 in which the resin is a thermoplastic resin suitable for forming hooks, comprising polypropylene, polyethylene, polyester, polystyrene, PVC, nylon or copolymers or polymer blends 15 thereof.

10. The method of claim 1 wherein the widthwise stretching process causes molecular orientation and strengthening of the base of the web between fastener elements as it is stretched such that as a result the 20 base of the web between fastener elements is stretched widthwise substantially uniformly throughout.

11. The method of claim 10 wherein said synthetic resin has a Characteristic Minimum Stretch Ratio and said mold roll defines fastener elements and other stretch- 25 limiting features over the area of the web, according to a predetermined pattern, the pattern selected such that the ratio of the width of the final web to the width of the web before widthwise stretching is substantially less than the Characteristic Minimum Stretch Ratio.

- 33 -

12. The method of claim 11 wherein the fastener elements and stretch-limiting features resist local stretching of the web.

13. The method of claim 11 wherein the stretch-limiting features are physical features of the product formed of synthetic resin integral with the base of the web, the method including the step of differentially heating the web being formed such that said fastener elements and said stretch-limiting features are rendered less stretchable than the base of the web.

14. The method of claim 1 comprising controlling the temperature of the web base as the web is stretched widthwise.

15. The method of claim 14 comprising immersing the fastener elements in a temperature-controlled liquid during the widthwise stretching.

16. The method of claim 14 comprising immersing the web base in a temperature-controlled liquid during the widthwise stretching.

20 17. The method of claim 14 comprising heating the web base in a heated liquid bath during the widthwise stretching, while leaving the fastener elements exposed to air.

25 18. The method of claim 1 wherein the step of stretching the web widthwise comprises stretching the web widthwise in a first stretch zone; maintaining the web at an intermediate, stretched width; and then

- 34 -

further stretching the web widthwise in a second stretch zone.

19. The method of claim 18 wherein the rate of widthwise stretching varies along the first stretch zone.

5 20. A method of producing a sheet-form fastener product comprising:

a. forming from synthetic resin a running web having a multiplicity of rows of discrete fastener elements integral with and protruding from at least one 10 side of the web, the elements facing in a substantially longitudinal direction, and

b. thereafter, under conditions in which the web is permanently stretchable, stretching the web in a bias direction in a manner that permanently stretches 15 the web between fastener elements, increasing the spacing of the fastener elements and orienting the rows of fastener elements in a direction diagonal to the machine direction, such that the elements face in a diagonal direction.

20 21. A method of producing a laminated sheet-form product having fastener elements, comprising:

a. forming from synthetic resin a running web having a multiplicity of discrete fastener elements integral with a base of the web and protruding from one 25 side of the web base in a pattern,

b. thereafter, under conditions in which the web base is permanently stretchable, stretching the web base widthwise to a wider width in a manner that permanently stretches the web base between fastener 30 elements and increases the widthwise spacing of the fastener elements while substantially maintaining the longitudinal spacing of the fastener elements, and

- 35 -

c. bonding an added material to the oppositely directed side of the web base.

22. The method of claim 21 wherein the bonding comprises passing the added material and web over a 5 roller under conditions in which the web base is heat-softened.

23. The method of claim 21 wherein the bonding comprises

applying an adhesive to either the added material, 10 or the web base, or both, and directing the added material and web to join to form a laminate.

24. The method of claim 21 wherein the bonding comprises heat-softening a surface of the added material, 15 and passing the added material and web over a roller such that the web base adheres to the heat-softened surface of the added material.

25. The method of claim 21 wherein the bonding comprises forcing the added material and web together 20 such that the web base adheres to the heat-softened surface of the added material.

26. The method of claim 25 wherein the added material and web are forced together against a roller by air pressure.

25 27. A method of producing a sheet-form fastener product comprising:

a. forming from synthetic resin a running web having a multiplicity of discrete fastener elements integral with the web and protruding from at least one

- 36 -

side of the web in a pattern, the forming causing the molecular structure of the web to be pre-oriented in a longitudinal direction, and

b. thereafter, under conditions in which
5 the web is permanently stretchable, stretching the web widthwise in a manner that permanently stretches the web between fastener elements and increases the widthwise spacing of the fastener elements while substantially maintaining the longitudinal spacing of the fastener
10 elements.

28. A fastener product comprised of synthetic resin and having multiple rows of fastener elements oriented in a first direction along a web base, the web portions between the rows of elements having molecular
15 orientation at a substantial angle to the first direction.

29. The product of claim 28 in which the fastener elements comprise hook elements with profiles set at a bias direction relative to the running length of the web.

20 30. The product of claim 28 in which said web base in stretched condition comprises a thermoplastic film of thickness less than about 0.003 inch.

31. A useful article having a non-planar surface to which is adhered the product of claim 30, the film web
25 conforming to said non-planar surface.

32. The product of claim 28 having a width of eight feet or more.

- 37 -

33. The product of claim 28 having molecular orientation in the widthwise direction providing tear resistance in the lengthwise direction.

34. The product of claim 33 also having molecular orientation in the lengthwise direction providing tear resistance in the widthwise direction.

35. A decorative covering comprising the product of claim 28 and a sheet material in a laminated state, the fastener elements of the product providing a means to secure said covering in a desired position.

36. The decorative covering of claim 35 comprising a wall covering.

37. The decorative covering of claim 35 comprising a floor covering.

38. A machine for forming a fastener product comprising a pair of rolls forming a nip, at least one of the rolls being a mold roll for forming touch fastener elements integral with a side surface of a running length of a web base, means for supplying plastic resin to the nip whereby the resin is longitudinally stretched before being molded, and a widthwise stretching device arranged to stretch the web base of an intermediate product produced by said pair of rolls in a direction transverse to the running length of said web base.

39. The machine of claim 38 including a heating tunnel through which said intermediate product is passed prior to said stretching device, the heating tunnel arranged to predominantly heat a side surface of the web

- 38 -

base opposite to the side surface on which the fastening elements are disposed.

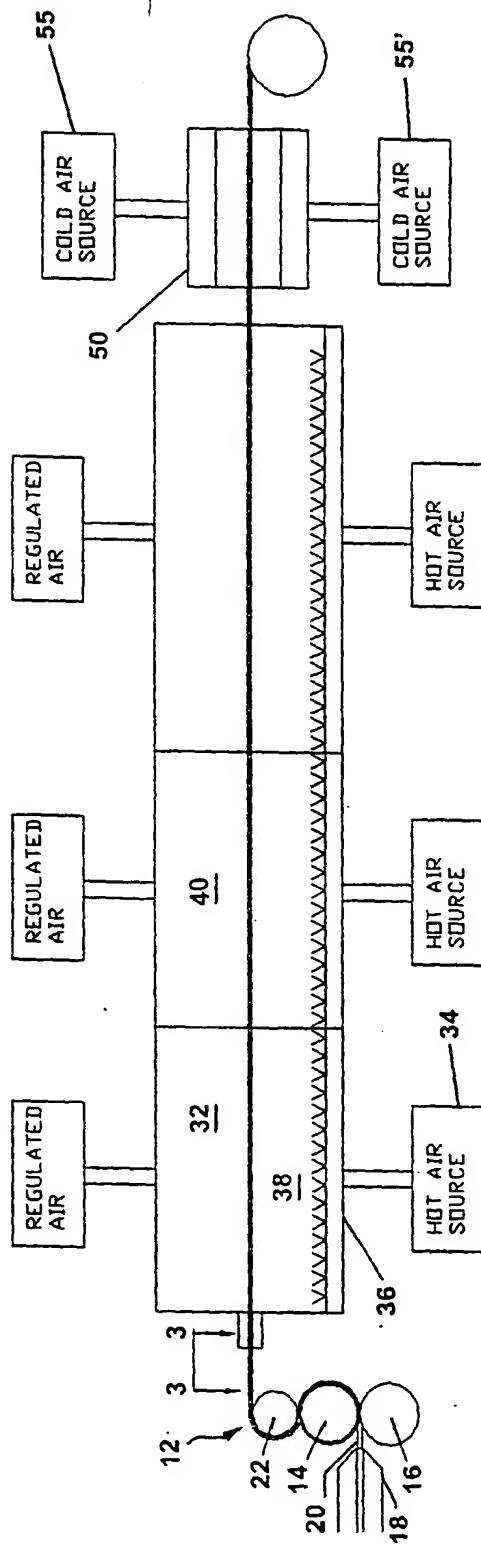
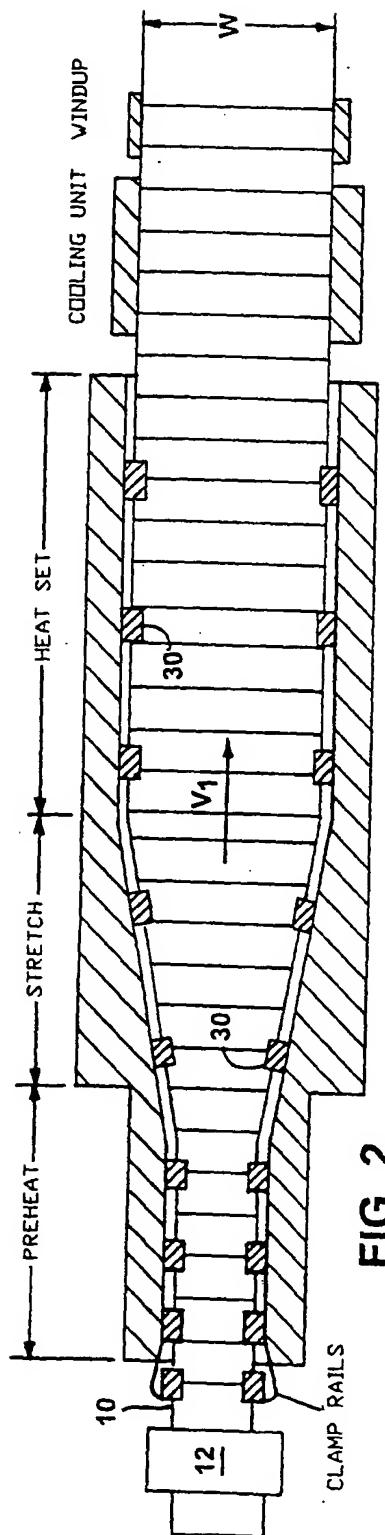
40. The machine of claim 38 wherein the means for supplying plastic resin comprises an extruder and the supplied resin is longitudinally stretched by tension caused by the driven rolls, thereby pre-orienting the molecular structure of the resin in the machine direction before forming.

41. The machine of claim 38 wherein the means for supplying plastic resin comprises an extruder positionable above the nip, and the supplied resin is longitudinally stretched at least partially by inertial forces as it falls from the extruder to the nip.

42. The machine of claim 38 including means for laminating an added material to the stretched web base.

43. The machine of claim 42 wherein the means for laminating an added material comprises a roller about which said product is trained in a stretched condition.

1/11



2/11

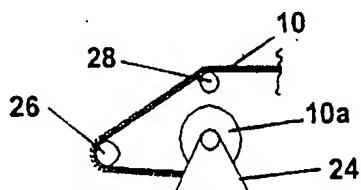


FIG. 1a

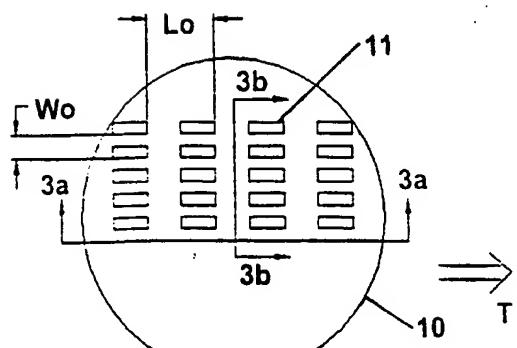


FIG. 3

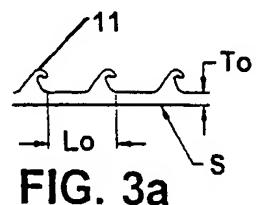


FIG. 3a

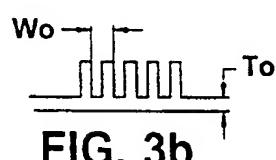


FIG. 3b

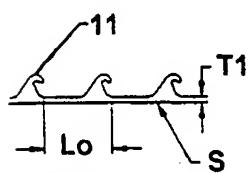


FIG. 5

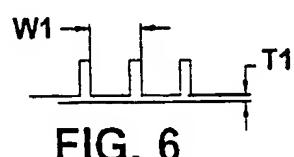


FIG. 6

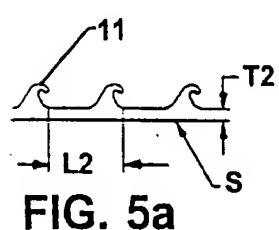


FIG. 5a

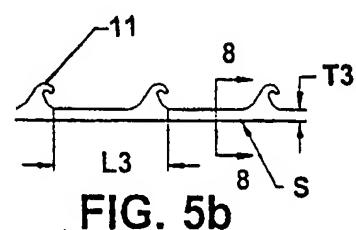


FIG. 5b

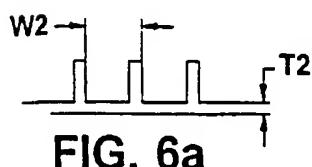


FIG. 6a

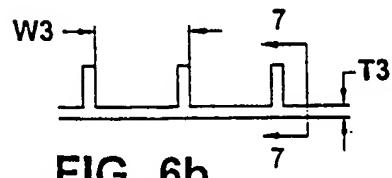


FIG. 6b

3/11

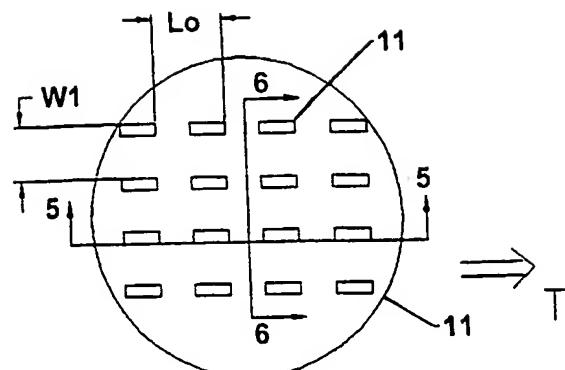


FIG. 4

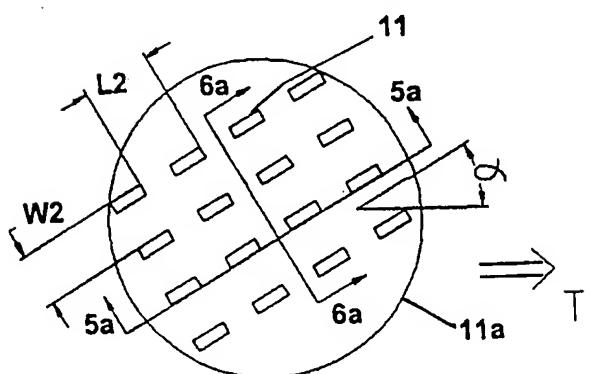


FIG. 4a

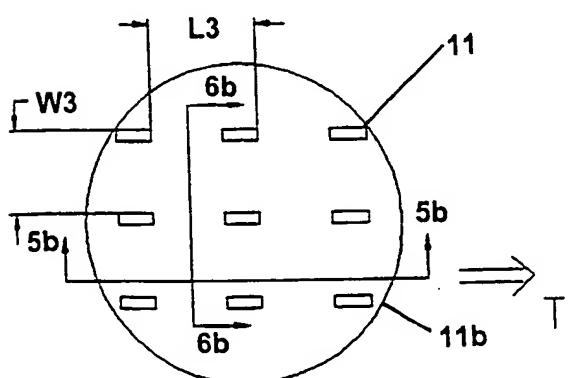
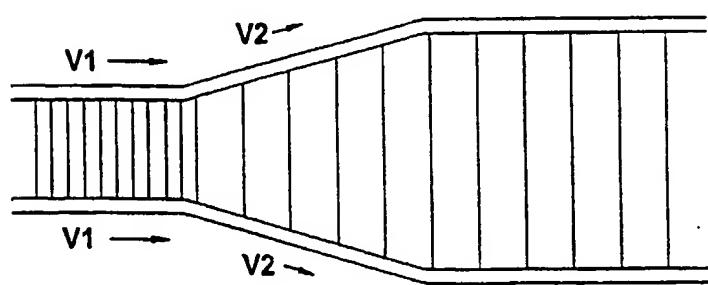
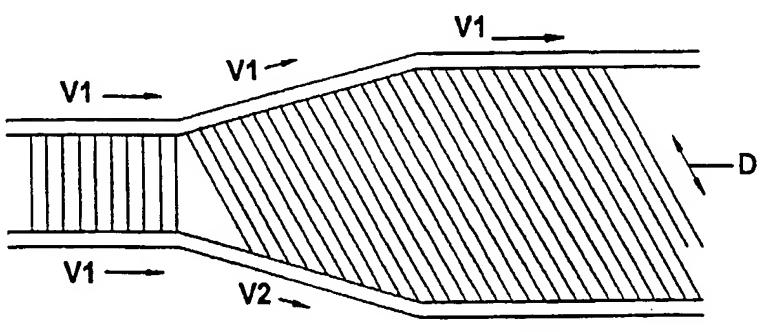
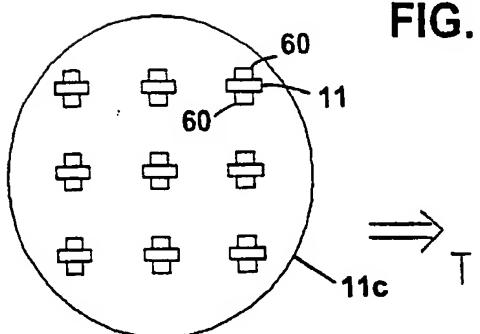
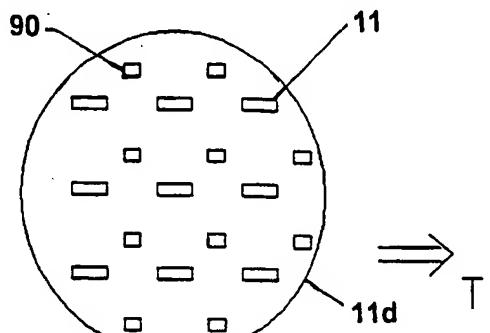


FIG. 4b

4/11



5/11

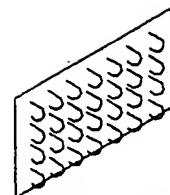


FIG. 10

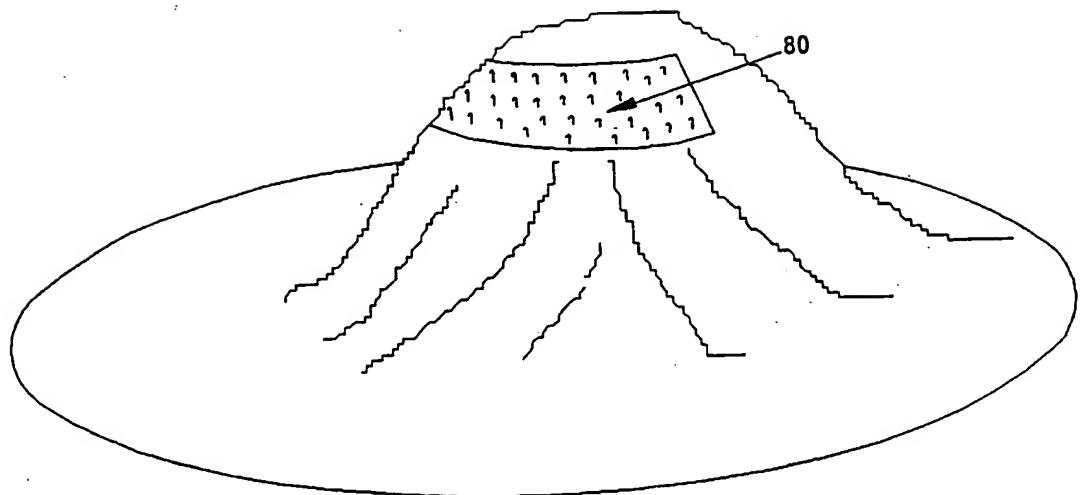
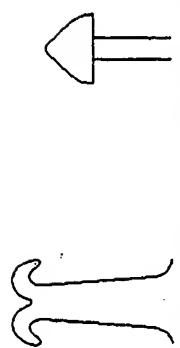
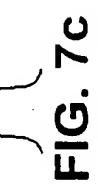
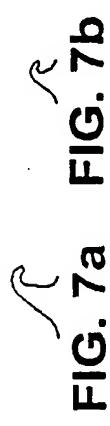
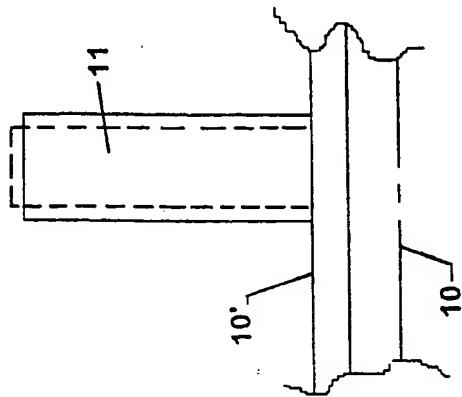
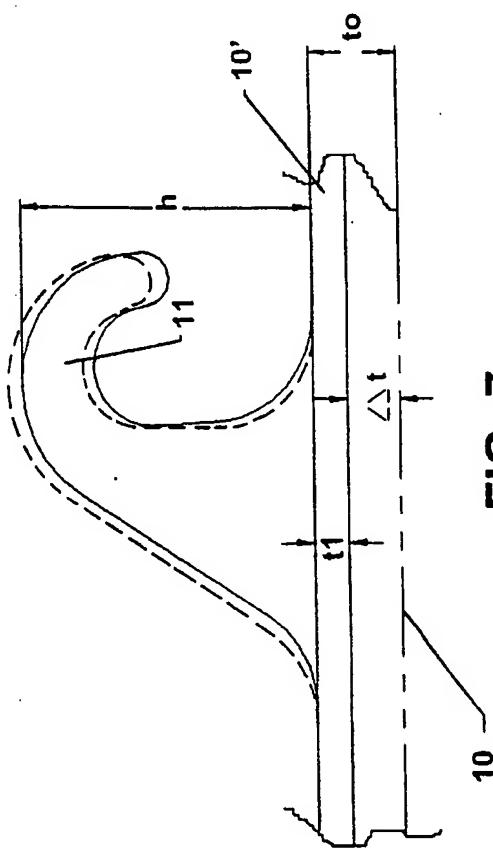


FIG. 9

6/11

**FIG. 7d****FIG. 7b****FIG. 7a****FIG. 8****FIG. 7**

7/11

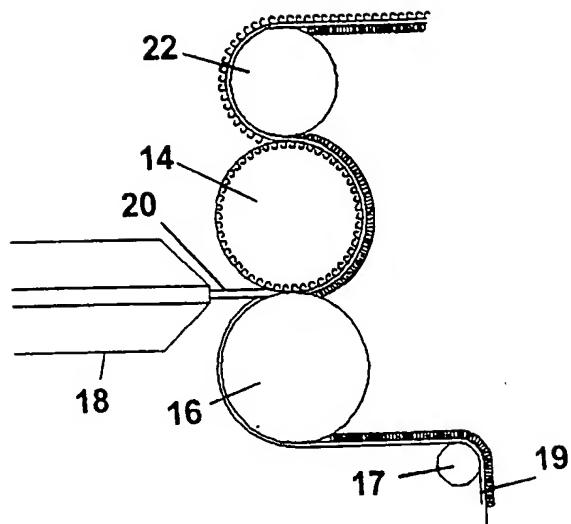


FIG. 13

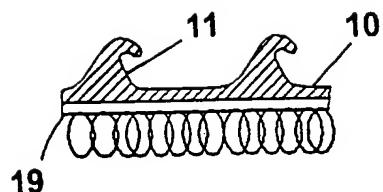


FIG. 13a

8/11

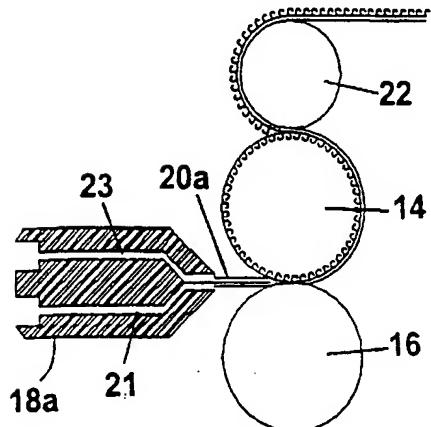


FIG. 14

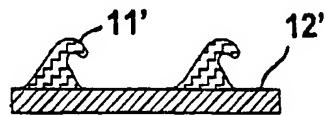


FIG. 14a

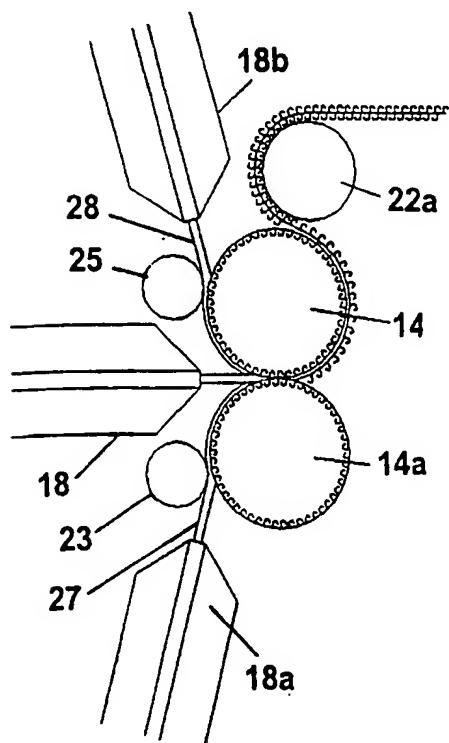


FIG. 15

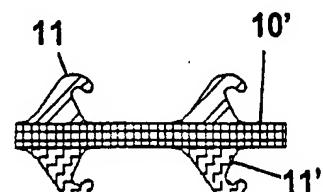


FIG. 15a

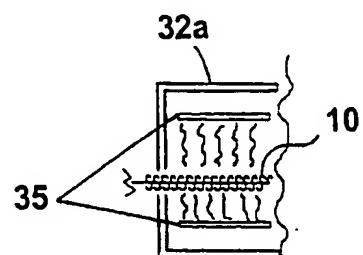


FIG. 16

9/11

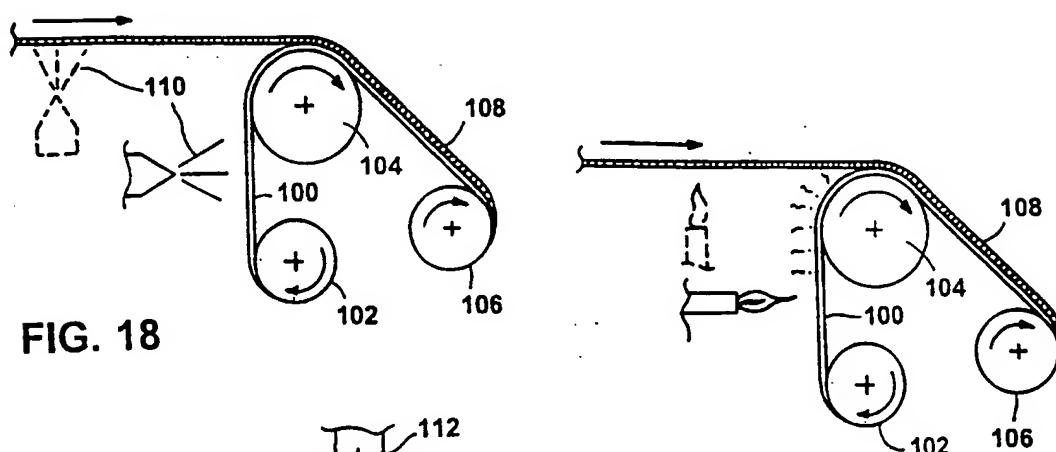
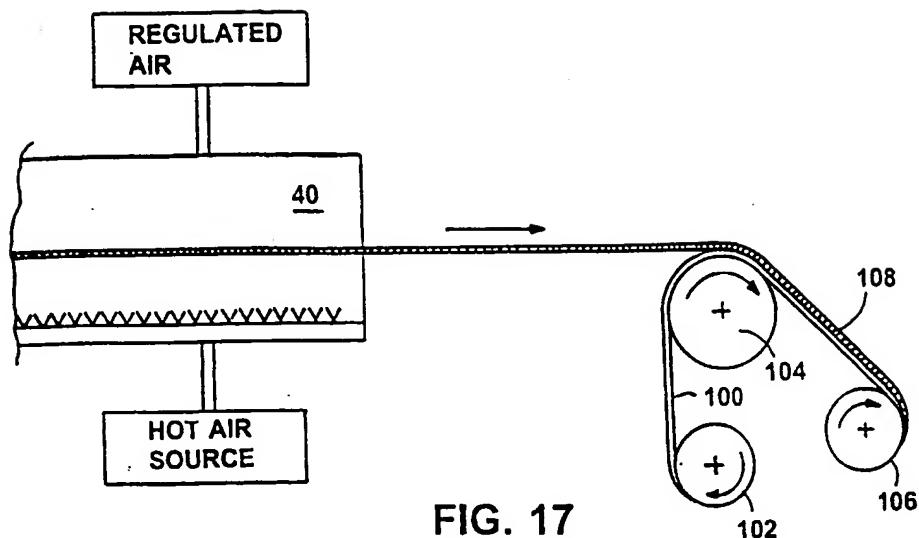
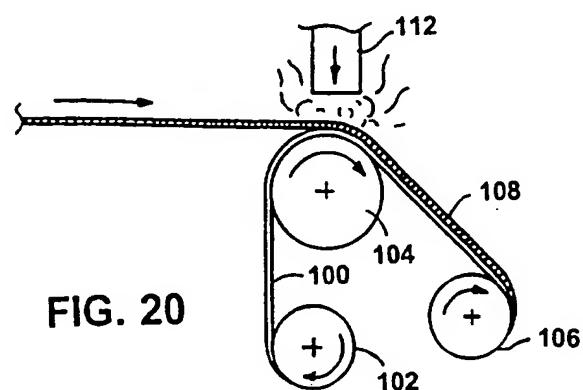
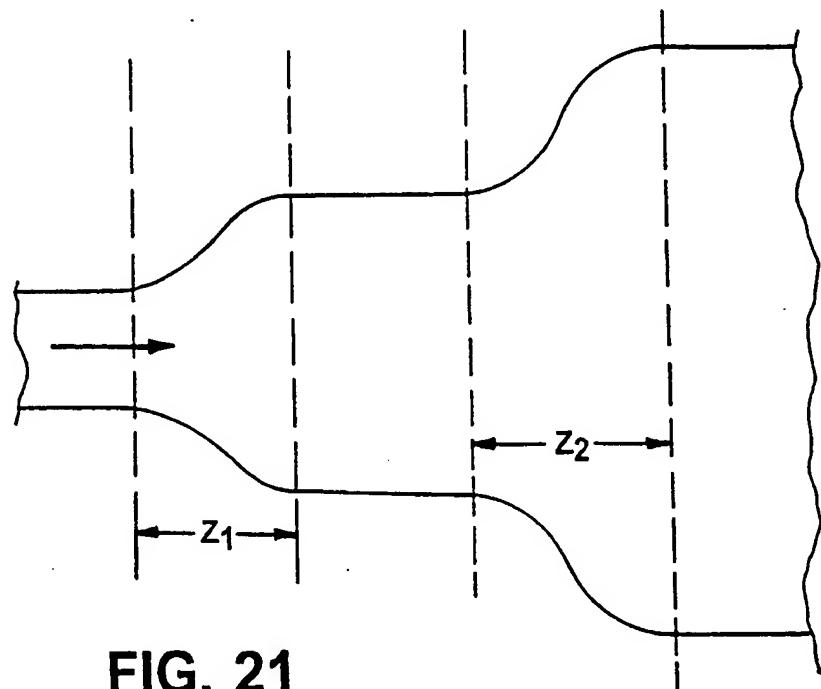
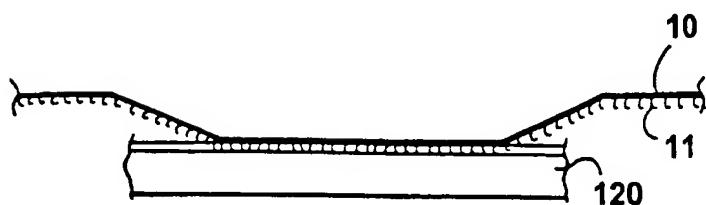
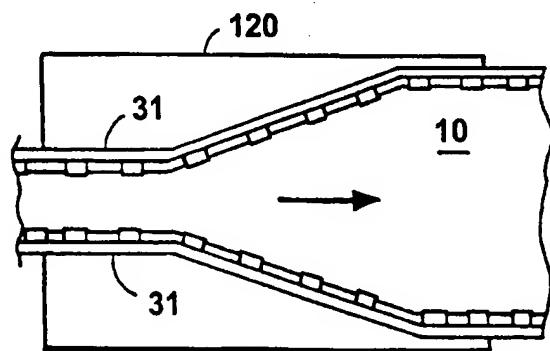
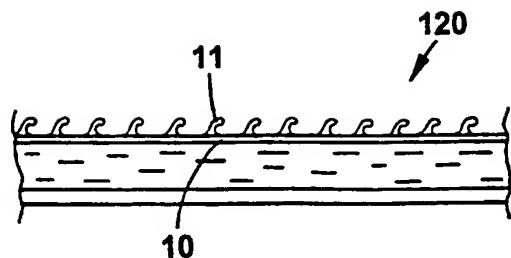
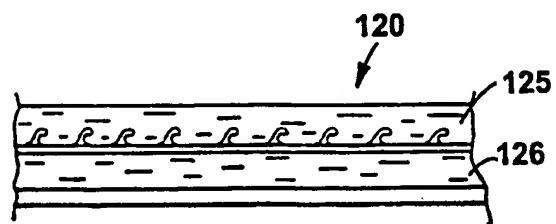
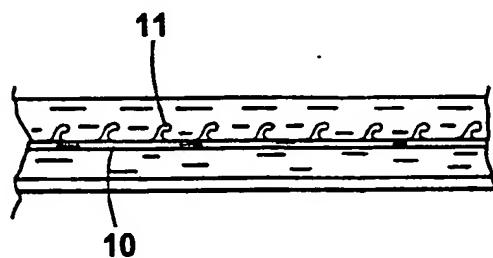


FIG. 19



**FIG. 21****FIG. 22****FIG. 23**

11/11

**FIG. 24****FIG. 25****FIG. 26**

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A44B 18/00;B29C 17/00;D06C3/00;B29D 5/00

US CL :24/442,450,452 ; 264/175,145,290;29/72,99

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 24/452,450,451,449,448,446,445,444,443,442;264/145,175,292;26/72,99

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,261,944 A (HUFNAGEL ET AL) 14 April 1981 (14/04/81); See entire document.	1-43
Y	US 3,833,973 A (SCHWARZ) 10 September 1974 (10/09/74); See entire document.	1-43
Y	US 5,230,851 A (THOMAS) 27 July 1993 (27/07/93); See entire document.	1-43
Y	US 3,954,933 A (RASMUSSEN) 04 May 1976 (04/05/76); See entire document.	1-43

Further documents are listed in the continuation of Box C. See patent family annex.

• Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"		document defining the general state of the art which is not considered to be of particular relevance
"B"		earlier document published on or after the international filing date
"L"		document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O"		document referring to an oral disclosure, use, exhibition or other means
"P"		document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search	Date of mailing of the international search report
04 MAY 1998	29 MAY 1998
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer VICTOR SAKRAN Telephone No. (703) 308-2224

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01271

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 2,929,329 A (HEILMANN) 05 February 1981 (05/02/81); See entire document.	1-43
Y	GB 1,437,005 A (KANEBO LTD.) 26 May 1976 (26/06/76); See entire document.	1-43
Y	GB 1,102,627 A (WYLDE) 07 February 1968 (07/02/68); See entire document.	1-43
Y	US 5,260,015 A (KENNEDY ET AL) 09 November 1993 (09/11/93; see entire document.	1-43
Y	US 4,794,028 A (FISCHER) 27 December 1988 (27/12/88); See entire document.	1-43
Y	US 4,140,826 A (LIU) 20 February 1979 (20/02/79); See entire document.	1-43
Y	US 5,144,786 A (PACIONE) 08 September 1992 (08/09/92); See entire document.	1-43
Y	US 5,512,234 A (TAKIZAWA ET AL) 30 April 1996 (30/04/96); See entire document.	1-43
Y	US 4,285,100 A (SCHWARZ) 25 August 1981 (25/08/81); See entire document.	1-43
Y	US 5,472,652 A (YOSHIMURA) 05 December 1995 (05/12/95); See entire document.	1-43
Y	US 5,455,992 A (KURURSCHATKE ET AL) 10 October 1995 (10/10/95); See entire document.	1-43
Y	US 4,677,011 A (MATSUDA) 30 June 1987 (30/06/87); See entire document.	1-43
Y	US 5,060,443 A (PACIONE) 29 October 1991 (29/10/91); See entire document.	1-43
Y	US 5,042,221 A (PACIONE) 27 August 1991 (27/08/91); See entire document.	1-43
Y	US 4,705,710 A (MATSUDA) 10 November 1987 (10/11/87); See entire document.	1-43

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3,230,134 A (STUDER) 18 January 1966 (18/01/66); See entire document.	1-43
Y	US 3,682,760 A (FAIRBANKS) 08 August 1972 (08/08/72); See entire document.	1-43
Y	US 4,235,834 A (VETTER ET AL) 25 November 1980 (25/11/80); See entire document.	1-43
Y	US 4,056,593 A (ALBAREDA) 01 November 1977 (01/11/77); See entire document.	1-43
Y	US 5,262,107 A (HOVIS ET AL) 16 November 1993 (16/11/93); See entire document.	1-43
Y	US 3,312,583 A (ROCHLIS) 04 April 1967 (04/04/67); See entire document.	1-43
Y	US 4,384,392 A (ALLEN) 24 May 1983 (24/05/83); See entire document.	1-43
Y	US 3,632,716 A (FAIRBANKS) 04 January 1972 (04/01/72); See entire document.	1-43
Y	US 3,694,537 A (FAIRBANKS) 26 September 1972 (26/9/72); See entire document.	1-43
Y	US 4,555,377 A (WHITESIDE ET AL) 26 November 1985 (26/11/85); See entire document.	1-43
Y	US 4,001,366 A (BRUMLIK) 04 January 1977 (04/01/77); See entire document.	1-43
Y	US 4,189,809 A (SOTOS) 26 February 1980 (26/02/80); See entire document.	1-43
Y	US 5,537,723 A (YOSHIDA ET AL) 23 July 1996 (23/07/96); See entire document.	1-43
Y	US 4,920,617 A (HIGASHINAKA) 01 May 1990 (01/05/90); See entire document.	1-43
Y	US 4,536,429 A (MERCER) 20 August 1985 (20/08/85); See entire document.	1-43

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01271

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,894,060 A (NESTEGARD) 16 January 1990 (16/01/09); See entire document.	1-43
Y	GB 1,022,715 A (MATHISON) 16 March 1966 (16/03/66); See entire document.	1-43
Y	US 4,672,722 A (MALAMED) 16 June 1987 (16/06/87); See entire document.	1-43
Y	US 4,970,039 A (LONG) 13 November 1990 (13/11/90); See entire document.	1-43
Y	US 5,137,661 A (KANOME ET AL) 11 August 1992 (11/08/92); See entire document.	1-43
Y	US 5,133,166 A (PACIONE) 28 July 1992 (28/07/92); See entire document.	1-43
Y	US 4,287,147 A (HUNGERFORD) 01 September 1981 (01/09/81); See entire document.	1-43
Y	US 4,409,160 A (KOGO ET AL) 11 October 1983 (11/10/83); See entire document.	1-43
Y	DE 1,785,284 A (GLARUS) 14 December 1972 (14/12/72); See entire document.	1-43
Y	US 4,368,565 A (SCHWARZ) 18 January 1983 (18/01/83); See entire document.	1-43

